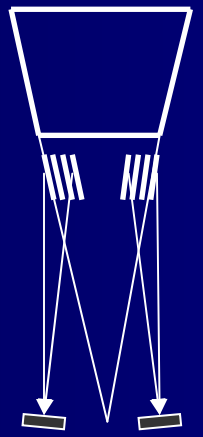
Off-plane concept & configuration for the X-ray Grating Spectrometer (XGS)

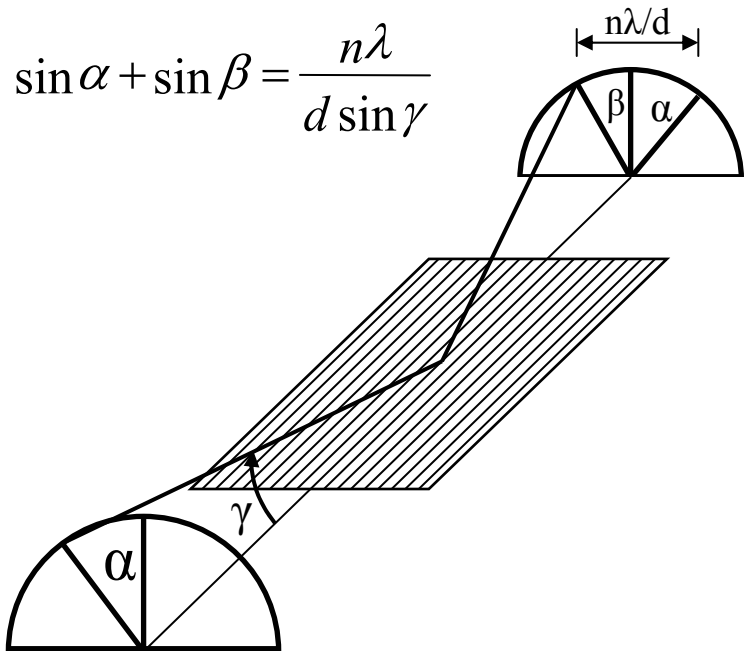
Randall L. McEntaffer, University of Colorado, Boulder

Off-plane concept

- Light intersects the grating quasi-parallel to the grooves and disperses into a cone with half-angle γ
- γ is low, typically < 4°, so gratings must be arrayed to intersect the telescope beam



$$\sin\alpha + \sin\beta = \frac{n\lambda}{d\sin\gamma}$$



Off-plane capabilities

- Resolution

$$R = \frac{2\theta \tan\alpha}{B}$$

B = telescope blur in radians given 15” for Con-X SXT

$\theta = \gamma$, graze angle = 2.7°

α = blaze in Littrow ($\alpha = \beta$ = blaze)

If α = 30° then R = 750, if α = 60° then R = 2500

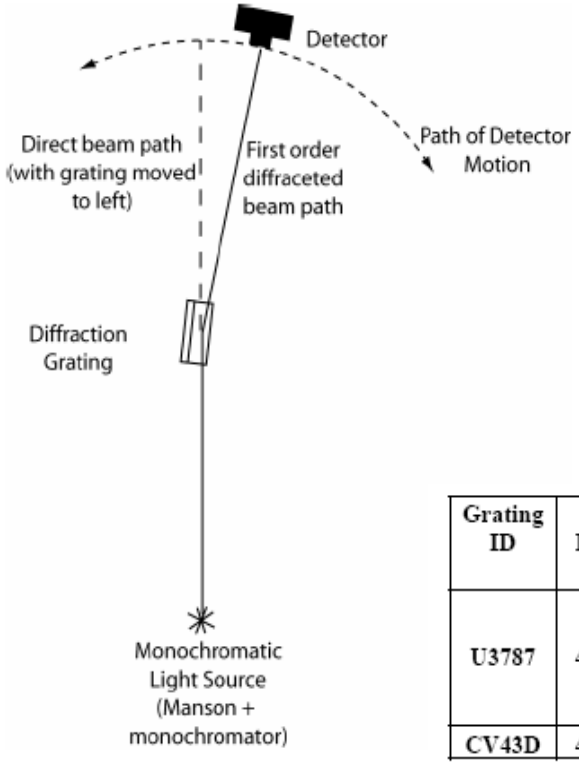
  - Increase using subaperture

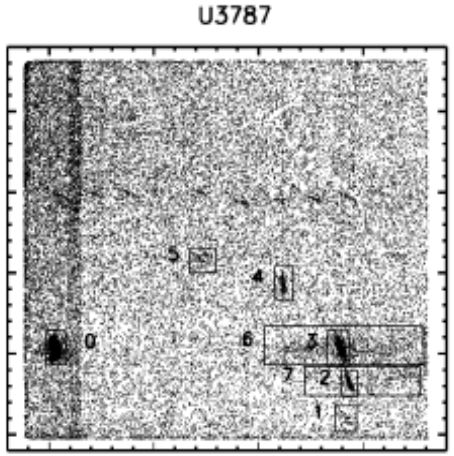
    Sample the blur function with grating modules

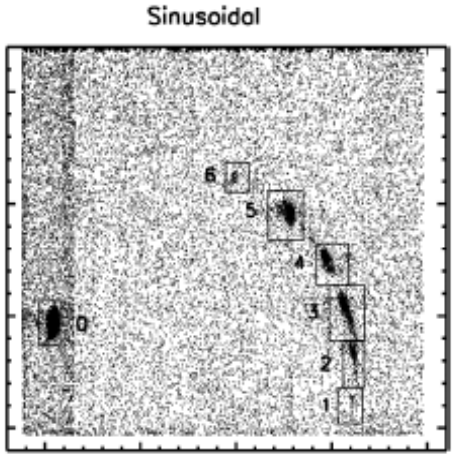
    A factor of 4 would be easily attainable and for a 30° blazed grating R = 3000 (requirement of R > 1250) .

    In the lab R > 200 for a 3’ telescope

Grating Efficiency







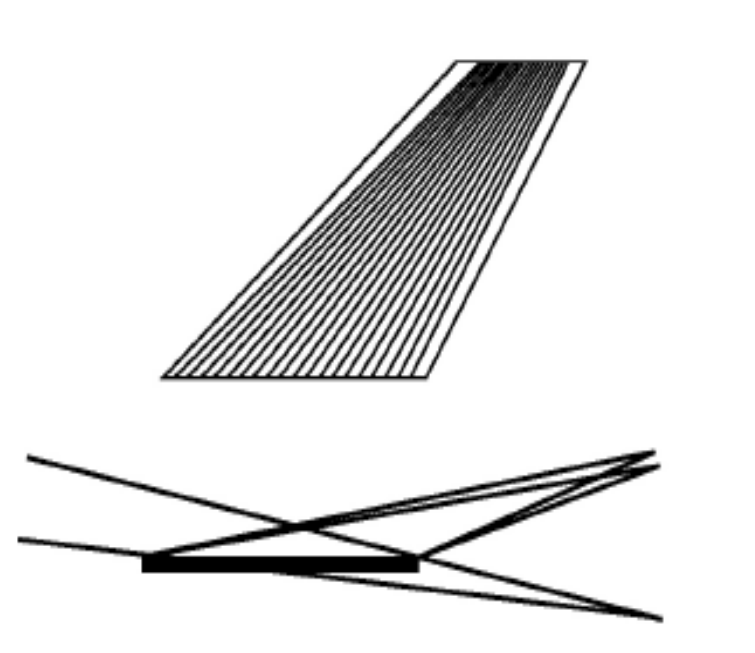
Grating ID	Line Density	Blaze	Source	Energy (keV)	Efficiency in Order (Efficiency with scatter in parentheses)					
					-2	-1	0	1	2	3
U3787	4245.83	9.1°	Carbon K	0.277	-	6.1	21.1	18.9	-	-
			Oxygen K	0.525	6.2	-	21.6	1.5	19.6	-
			Mg-K	1.25	-	3.0	0	19.2 (31.8)	2.7 (5.4)	0.3
CV43D	4245.83	Sinusoidal	Mg-K	1.25	1.4	18.4	7.6	15.2	4.3	0.4

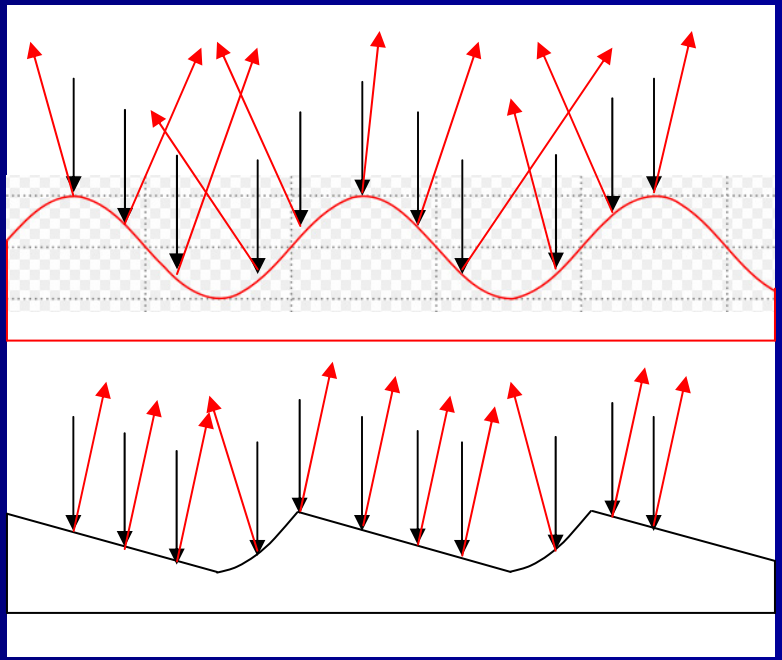
40% efficiency in diffracted orders

Con-X Requirements

- Resolution
  - R > 1250 (increased from 300)
    - R > 200 for 3' telescope
      - 15" telescope → R > 2400
- Effective area
- A_{eff} = 1000 cm^2 below 1keV
  3 m^2 collecting area SXT
  → 7500 cm^2 per telescope @ >75% reflectivity
  → 5625 cm^2 in one telescope
  RGS coverage 70% with 40% efficiency
  → 1575 cm^2 *in a single telescope*

Off-plane grating development





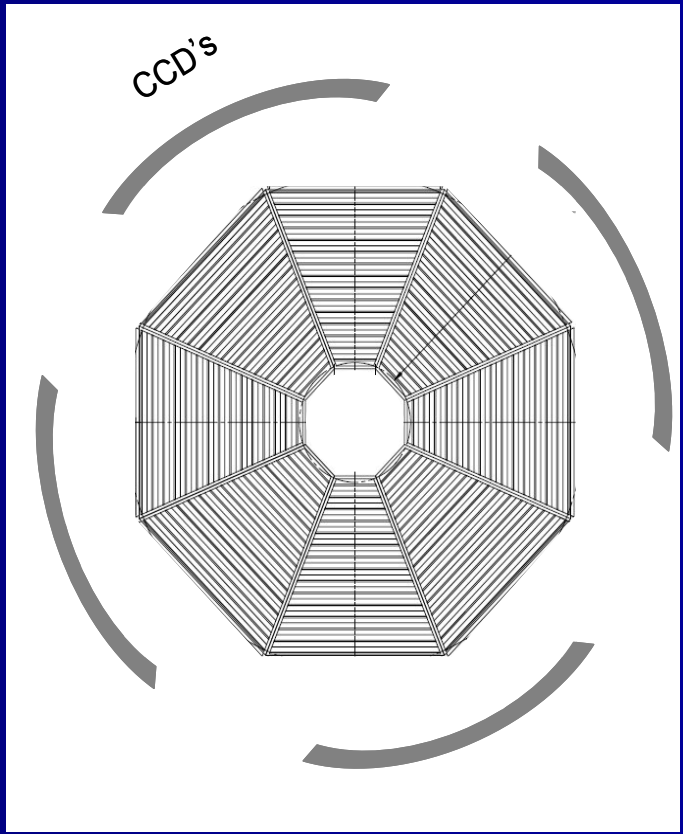
Systems development

- JY fabricated a radial blazed master for use with the XMM flight spare
  - Panter X-ray test facility Max-Planck
- Test with Con-X Soft X-ray Telescope instead
  - Will Zhang @ Goddard

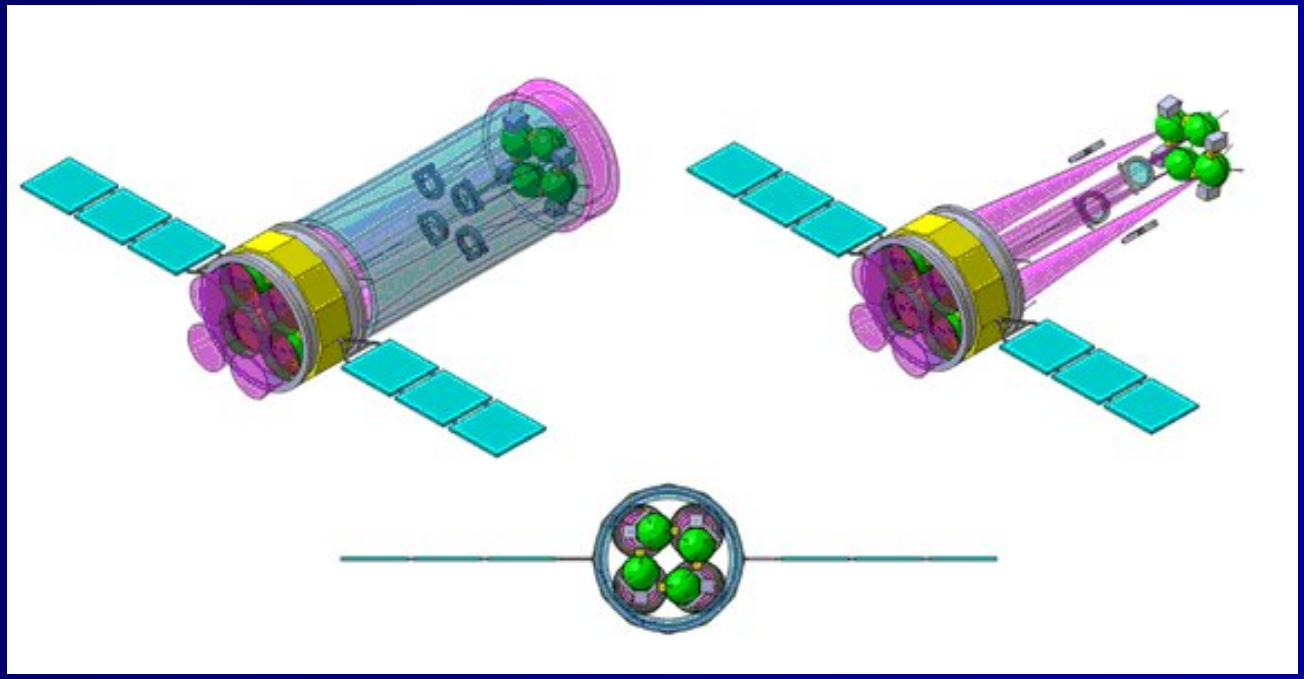
- **Located on ground and far from traffic**
- **Total Length of 600 meters**
  - **10 inch diameter Steel Pipe**
- **Three stations along the length:**
  - **Prefab 12'x24' barns**
  - **Installed Insulation and heatpumps**
  - **Phone/Internet Connections for remote operation**

Flight configuration

- If arranged on one telescope the gratings can be arranged in octant modules that feed 4 separate CCD arrays to achieve subaperture
- If on multiple telescopes, these octants/CCD arrays can be separated and split among the telescopes



Configuration



- Can also fully cover all telescopes and actuate modules in and out of beam → $A_{eff} > 6000\ cm^2$
- Possibly not feasible given mass constraints on XGS